Question Bank

B.Sc. Part III

Paper I - Quantum Mechanics

1. What is photoelectric effect?
2. State De-Broglie hypothesis.
3. The De-Broglie wavelength for an electron is $2x10^{-2}$ m find the kinetic energy of electron?
4. Calculate the maximum change in the wavelength of an incident photon of wavelength $1A^0$?
5. Discuss the Planck hypothesis for Black body radiation?
6. Prove that the group velocity of wave packet is equal to the particle's velocity.
7. Define Hermitian operator.
8. What is the value of commutator $[z,p_z]$.
9. Explain the concept of parity?
10. Draw the first four eigen functions for a particle in 1 D infinite potential well.
11. For the angular momentum operator L, show that L^2 commutes with L_Z.
12. Calculate $<r^2>$ for H- atom in its ground state?
13. What is Raman Effect?
14. Name the lines arising from ΔJ=-1, 0, +1?
15. Discuss Normal Zeeman effect.
16. (a) Explain Compton Effect. Derive an expression for Compton shift. What do you mean by Compton wavelength?
    (b)Calculate the de Broglie wavelength associated with thermal neutrons of temperature 27^o C.
17. What is a wave packet? Explain construction of 1-D wave packet using principle of superposition. Also prove that the group velocity of wave packet is equal to the particle's velocity.
18. Write the time independent Schrodinger equation for particle moving in a one dimensional potential box and solve it to find Eigen function and Energy Eigen values. Discuss differences in classical and quantum results.
19. Obtain the energy Eigen values and Eigen functions for a particle in one dimensional infinite potential well. Show that Eigen functions are orthogonal.
20. Explain normal and anomalous Zeeman Effect. Give energy level diagram for sodium atom showing Zeeman Effect in D lines.

21. Determine transmission coefficient and reflection coefficients for a particle of positive energy moving through one dimensional square well potential. Explain resonant scattering.
22. Write the energy eigen values and eigen functions of one dimensional simple harmonic oscillator for the first four states. Sketch these Eigen functions and determine their parity.
23. What is the effect of spin-orbit coupling on a s-state and on a p-state of alkali atoms? Explain.
24. Write characteristics features of alkali spectrum alternatively. Write the alkali features of spectra of one electron atom.
25. (a) What is Planck's quantum hypothesis? Derive average energy of Planck's Oscillator. Also derive Planck's radiation law. Deduce Wien's displacement and Rayleigh- Jeans law from Planck's radiation law.

    (b) Prove that Eigen functions of a Hermitian operator for two distinct Eigen values are orthogonal.

Paper II-Nuclear Physics

1. What is meaning of parity?
2. Find the values of parity of following –
   a) $_3Li^7$ b) $_7N^{15}$
3. What are basic characteristics of nuclear forces?
4. Define mass defect, Packing fraction and binding energy?
5. What is meant by half-life and mean life?
6. What do you mean by critical mass?
7. What do you understand by controlled chain reaction?
8. Name conservation laws which are conserved in nuclear reaction?
9. Write down the Bethe-Bloch formula for energy loss?
10. What is Plateau region in GM Counter?
11. What is Paralysis Time?
12. Write down the principle of Betatron?
13. What is the limitation of linear accelerator?
14. What are leptons?
15. What are Quarks?
16. Explain Quadrupole moment of nucleus and deduce its expression using classical mechanics?
17. Describe various section of a nuclear reactor with the help of suitable diagram?
18. Describe the process of achieving quenching in Geiger-Muller Counter?
19. Describe Construction and working of a linear accelerator .What are its limitations?
20. What are quarks? Illustrate constitution of proton and neutron on the basis of quark model?
21. What is the meaning of electrical quadrupole moment of a nucleus? Derive an expression for it. What conclusions can be drawn from the knowledge of quadrupole moment of a nucleus?
22. Derive the expression for the energy loss by the low energy heavy charged particle in a medium.
23. Discuss the principle and working of the ionization chamber for the detection of charged particles.
24. Describe construction and working of a linear accelerator and what are its limitations.
25. Explain bosons, leptons, fermions and hadrons with examples .Describe the meaning of strangeness.

Paper III - Solid State Physics

1. What do you understand by Bravais lattice?
2. Find the formula for inter planar distance for a cubic crystal?
3. Differentiate between primitive cell, unit cell, and crystal lattice.
4. Calculate the value of (h k l) of planes possible having the value of $(h^2+k^2+l^2) = 6$.
5. How are X-rays helpful to determine crystal structure?
6. Prove that reciprocal lattice of FCC is a BCC lattice.
7. Discuss the effect of periodic potential on E-K diagram.
8. How the velocity of an electron vary in a periodic potential? Explain.
9. What are Bloch electrons?
10. What is coordination number?
11. What are the main assumptions of Kronig-penny model?
12. Define the term 'forbidden gap'.
13. Explain the concept of hole.
14. How is the orbital frequency of the atomic electron in an diamagnetic material affected on the application of external field?
15. State the Curie's law and for which material's is it obeyed?
16. How are cooper pair formed. Explain qualitatively the BCS theory of superconductivity and discuss the energy gap based on this theory. Using the properties of superconductors prove that the superconductors behaves as perfect diamagnet.
17. Determine the fundamental vectors, volume of a primitive cell and packing fractions for simple cubic, BCC, FCC and hexagonal closed paced structure. Show that the packing fractions of FCC and HCP structures are equal.
18. Discuss Kronig Penny model for the motion of an electron in a periodic potential and solve it for

$$\frac{P \sin \alpha a}{\alpha a} + Cos \propto a = CosKa$$

    On the basis of this solution explain the formation of energy bands in solids.
19. Explain Debye model for specific of solids. Prove that specific heat of solids at law temperature is proportional to T^3 where T is absolute temperature.
20. Explain Meissner effects in superconductivity also explain type I and type II superconductors.
21. Derive London's equation for superconductor and prove from it that London penetration depth is given by

$$\boldsymbol{\lambda} = \sqrt{\frac{m}{q^2 n_s \mu_0}}$$

    Where n_s is number density of super electrons
22. Derive Bragg Equation for X-ray diffraction. Explain the conditions for x-ray scattering from crystal. Why Bragg law is not applicable to visible light. The Bragg angle

corresponding to first order reflection from (200) plane in a crystal is 16.6°. When x-rays of wavelength 1.54Å are used. Calculate the lattice constant.

23. State and prove Bloch theorem. Explain how effective mass of an electron in a periodic lattice varies with wave vector k and give physical significance of negative mass.
24. Explain classical theory of specific heat for solids and hence deduce Dulong Petit law.
25. (a) Describe the potential energy an any ionic crystal and plot the graph. If potential energy of a molecule is expressed as

$$U(x) = \frac{a}{r^{12}} - \frac{b}{r^{6}}$$

Prove that the potential energy will be minimum at distance r= $(2b/a)^{6}$.

(b) Find the miller indices of a cubic plane which intercept the axes in the ratio

(i) 3a:2b:c

(ii) a:2b:c